SURFACE MANAGEMENT SYSTEM

RESEARCH & DEVELOPMENT PLAN

VOLUME I – TECHNICAL PLAN

SMS-101

December 30, 1999

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER
COMPUTATIONAL SCIENCES DIVISION
MOFFETT FIELD, CALIFORNIA

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SURFACE MANAGEMENT SYSTEM (SMS)

RESEARCH & DEVELOPMENT PLAN

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REVISIONS

No.	Date	Comments
0	12/30/99	Original Issue

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SURFACE MANAGEMENT SYSTEM (SMS)
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VOLUME I – TECHNICAL PLAN

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SMS-101, Volume I
Orig. Issue Date 12/30/99
Revision No. ____________

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VOLUME I – TECHNICAL PLAN

SMS-101

This document is a part of the SMS Documentation which is controlled by the NASA/ARC Aviation Surface Technologies (AST) Area Team, Moffett Field, California. For additional official versions of this document, please address your request to:

Mr. David Signor
NASA/ARC SMS Level IV Lead
Mailstop N269-4
NASA/Ames Research Center
Moffett Field, California 94035 - 1000

Prepared by:

Aviation Surface Technologies Area Team Systems Engineer	Christopher Leidich	Date
SMS Level IV Lead	David Signor	Date

Approved by:

Aviation Surface Technologies Area Team Lead	Yuri Gawdiak	Date
Computational Sciences Division Chief	Dr. Peter Norvig	Date

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SMS-101, Volume I
Orig. Issue Date 12/30/99
Revision No. ____________

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RESEARCH & DEVELOPMENT PLAN

VOLUME I – TECHNICAL PLAN

SMS-101

1.0 INTRODUCTION

This document describes the technical plan for the Surface Management System (SMS) research and development. This effort includes:

a) the development of an Operations Concept for the SMS Prototype (see Ref. 1 in Section 2.3)

b) the development of national SMS User Requirements (Level I)

c) the development and assessment of research prototypes (these prototypes will validate portions of the SMS Concept of Operations and the SMS User Requirements)

Refer to Section 3.0 for a breakdown and approach of the SMS research and development effort.

Volume II of this document describes the cost plan.

Refer to document SMS-102, Operations Concept for the SMS Prototype, for a description of the proposed SMS prototype (see Ref. 1 in Section 2.3).

1.1 RESEARCH OBJECTIVES

The primary objective of the SMS research prototype developed at NASA/ARC will be to contribute to the understanding and solution of various problems existing within the surface domain of airports within the National Airspace System (NAS). Examples of traffic problems on the surface of the airport terminals in the NAS are terminal volume (amount of traffic), surface congestion and throughput. However, a complete list of known problems facing every user (FAA, Airline, City) and every airport is not appropriate here. A thorough description of the NAS, including problem areas and planned enhancements, described in reference 4 in Section 2.3.

The primary objective of SMS is directly related to the goals of other programs, either internal or external to NASA. For example, Collaborative Decision Making (CDM)/Flight Schedule Monitor

(FSM) desires knowledge of, as early as possible, the expected departure (a.k.a., wheels-up or wheels-off) time of every aircraft.

The secondary objectives of the SMS are to (1) demonstrate commonality and portability (between airports), and (2) integrate with CTAS tools as appropriate.

SMS at DFW will be integrated with various CTAS tools, for the purpose of providing surface information to arrivals and departures, shown below in Figure 1.1.

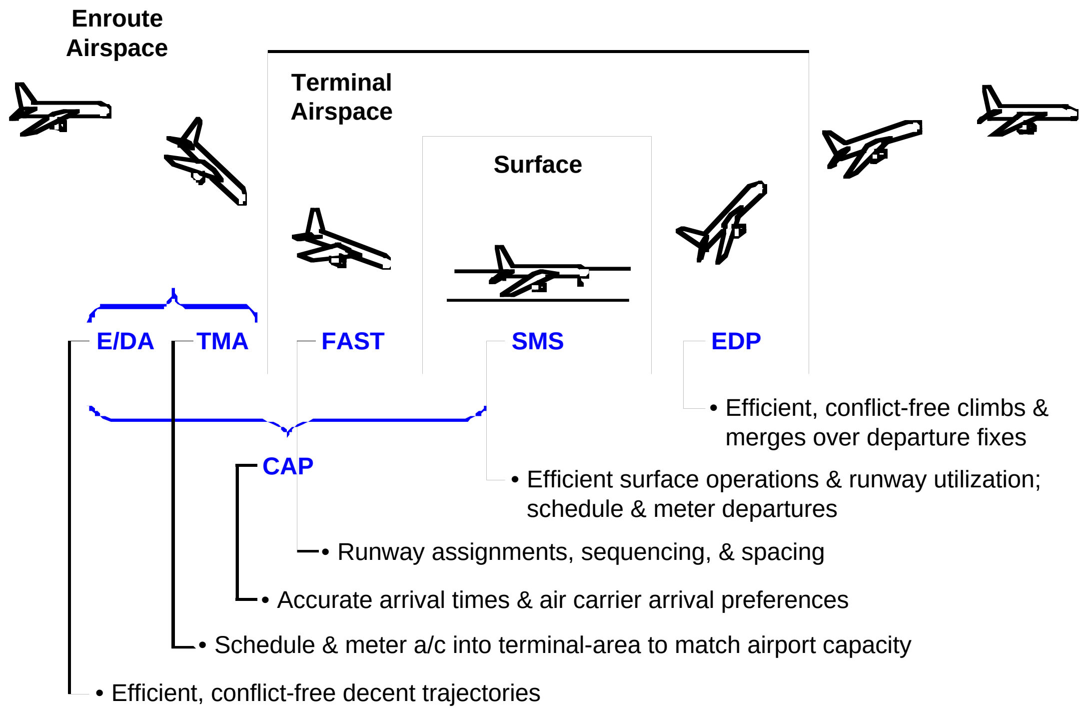

FIGURE 1.1
NASA EXTENDED TERMINAL AREA
AIR TRAFFIC MANAGEMENT DECISION SUPPORT TOOLS

1.2 SCHEDULE/MILESTONES/DELIVERABLES

The Advanced Air Transportation Technologies (AATT) Program Office at NASA/ARC has overall management responsibility of the Surface Management System (SMS) R&D Level-IV Task Area. The scope of the current SMS R&D covers a planned six-year period, which began in FY1998, and concludes (with a summary report) at the end of FY2003. Several interim status reports will be published during this period. Additional SMS R&D may occur after this period depending on future planning & funding.

The scope of the SMS effort is to conduct research into understanding the problems that exist on the airport surface within the NAS, to develop algorithms that will increase airport throughput, minimize ramp/taxiway congestion, and decrease taxi-delays, and to publish the results. Results will first be made available to the users (FAA, Airlines & Airport Operators). Any results published elsewhere will be reviewed by the users and published only with their permission.

An SMS prototype will be integrated with the Center Terminal Radar Approach Control (TRACON) Automation System (CTAS) and the other AATT applications, at Dallas-Fort Worth International Airport (DFW) (see Section 4.3). SMS will also be integrated with other tools, such as Collaborative Decision Making/Flight Schedule Monitor (CDM/FSM). Wherever possible, integration at a national level will be pursued.

The primary technical metric used in the AATT Program is based on the NASA Technology Readiness Level (TRL) scale shown below in Figure 1.2. (taken from the Aviation System Capacity Program, AATT Program Plan).

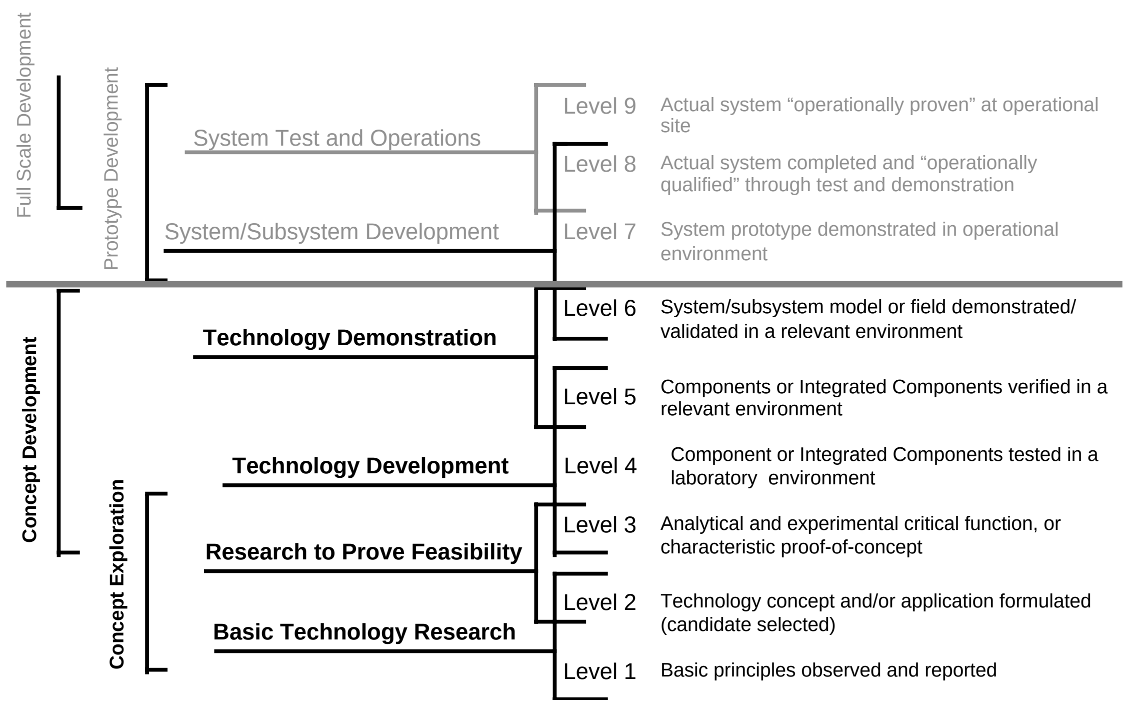

FIGURE 1.2
NASA TECHNOLOGY READINESS LEVEL METRICS

The relevant and annotated AATT milestones, taken from the "Terminal/Surface Systems and Operations Level III Plan, (Ref. 3) are included below. The current official list of AATT milestones should be obtained directly from this document. SMS research must meet the following AATT milestones shown below in Table 1.2 (from the AATT Terminal/Surface Systems & Operations Level III Plan). Milestones in Italics are Interoperable Arrival/Surface/Departure Operations Milestones from reference 3 in Section 2.3.

TABLE 1.2
SMS R&D MILESTONES

Q2FY98 (3/31/1998) Milestone 6.10: SMS concept complete. (TRL 1 Decision)
Exit Criteria: SMS concept report.
Comments: Version 0 of this report was released. The first version of this document was submitted in June of 1999. The current document (December 1999) is a significant revision to the preceding version.

Q4FY98 (9/30/1999) SMS/CTAS interoperability initial concept.

Q1FY00 (12/31/1999) Milestone 6.14.1: SMS research plan complete. (TRL 2 Decision)
Exit criteria: Research plan report.
Comments: This includes details about the research to be conducted, algorithms currently being developed and collaborative partnerships utilized to meet the program milestones. Report to be published.

Q1FY00 (12/31/1999) SMS/CTAS demonstration of data exchange.

Q1FY00 (12/31/1999) SMS/CTAS interoperability design review.

Q4FY00 (9/30/2000) Milestone 6.14.2.1: Surface traffic monitor module verification in simulation.
Exit criteria: Report of results.
Comments: SMS algorithm simulation - TAAM will be the first tool used to investigate which taxi delay minimization and sequencing algorithms are expected to perform the best (in the real world). In addition to TAAM, analysis of data, and use of Future Flight Central (FFC, previously SDTF) will be pursued. The schedule for running SMS simulation in FFC is not currently known. All predictive algorithms will be simulated prior to being fielded in any prototype application.

Q1FY01 (12/31/2000) Milestone 6.14.2: SMS technical feasibility work complete. (TRL 3 Decision)
Exit criteria: SMS feasibility report.
Comments: An interim report - documenting findings to date, and describing the feasibility of SMS concepts.

Q2FY01 (3/31/2001) Laboratory demonstration of CTAS/SMS interoperability.

Q3FY01 (6/30/2001) Plan for integrated simulation demonstration of arrival/surface/departure ATM concepts.

Q4FY01 (9/30/2001) Milestone 6.14: SMS research prototype complete. (TRL 4 Decision).
Exit criteria: Initial SMS prototype functional description.
Comments: Any SMS prototypes will be built as research tools (as much as they serve the user needs). Thus, the national SMS research prototype is planned to be complete by 9/30/01. Various manifestations of the national SMS research prototype (fielded applications) will be in service by 9/30/01. Report to be published.

TABLE 1.2
SMS R&D MILESTONES (CONTINUED)

Q1FY02 (12/31/2001) Demonstration of CAP/TMA/AFAST/SMS/EDP interoperable system.

Q3FY02 (6/30/2002) Milestone 8.10.1.1: SMS simulations complete.
Exit criteria: Report of results.
Comments: The results from the completed SMS simulations will be published.

Q1FY03 (12/31/2002) Milestone 8.10.1: Validation of SMS. (TRL 5 Decision)
Exit criteria: Report of results.
Comments: IV&V will be conducted on the SMS concepts, and prototypes. Report to be published.

Q4FY03 (9/30/2003) Milestone 8.10: SMS operational evaluation complete. (TRL 6 Decision)
Exit criteria: Report of field test results.
Comments: The operation of fielded research prototypes will be evaluated, and results (including lessons learned and future recommendations) will be published.

Q2FY04 (3/31/2004) Field site demonstration of interoperable arrival/departure DST's.

SMS R&D will include but will not be limited to the above milestones. Within the time and resource constraints of this program, every effort will be made to determine practical solutions and implement research prototypes regarding airport surface problems within the NAS. SMS R&D beyond 9/30/2003 are not currently scheduled. Additional SMS R&D may occur after this period depending on future planning & funding.

1.3 RESEARCH TEAM

The NASA/ARC SMS research team members are listed below.

SMS Level IV Lead	David Signor
ATC Analyst	James McClenahen
Programmer	TBS
Network Support	Tony Lisotta
Programmer	Jeff Gale
Programmer	John Day
SMA Site Mgr/SMS System Engineer	Christopher Leidich
SMA Site Analyst	Steve Benoist
System Admin Support	Oleg Mitine
System Architect Lead	Jim Gibson
Test Engineer	TBS

Collaborative research with the Massachusetts Institute of Technology (MIT) and MIT Lincoln Labs (MIT/LL) will be undertaken to meet the SMS objectives. Collaboration with Metron and the Federal Aviation Administration (FAA) to integrate their work with NASA Surface research and development is underway. Collaborations with various airports, airlines & unions is anticipated.

Contact Information:

John Gordon, Level III Terminal/Surface Project Manager
Inter-Agency Integrated Product Team (IAIPT)
NASA, Ames Research Center
MS 210-6, Code AF
Moffett Field, CA 94035
Phone: (650) 604-2763
E-mail: jgordon@mail.arc.nasa.gov

David B. Signor, Level IV Surface Research Program Manager
NASA, Ames Research Center
MS 269-3, Code IC
Moffett Field, CA 94035
Phone: (650) 604-4562
Fax: (650) 604-4036
E-mail: dsignor@mail.arc.nasa.gov

Steve Atkins, Terminal/Surface Systems Integration
NASA, Ames Research Center
MS 210-6, Code AF
Moffett Field, CA 94035
Phone: (650) 604-2656
E-mail: satkins@mail.arc.nasa.gov

2.0 DOCUMENTATION

2.1 CHANGE CONTROL PROCESS

This document incorporates the current SMS baseline. A “TBS” denotes an information item to be supplied. A preliminary estimate is a value in parentheses that follows a TBS. Removal, addition, or changes of TBS’s and information contained herein may only be accomplished through the NASA/ARC Aviation Surface Technologies (AST) Area Team Configuration Control Process.

2.2 RESEARCH AND DEVELOPMENT DOCUMENTS

SMS R&D documentation will include areas such as requirements, design reviews, code specs, version controlled documentation, reports, testing results, safety, legal, logistics and deliverable. Refer to the website to assure you have the latest version:

http://ace.arc.nasa.gov/cgi-bin/postdoc/get/postdoc/t/folder/main.ehtml?url_id=10763

TABLE 2.2
SMS RESEARCH DELIVERABLE DOCUMENTATION

PLANS & PROCEDURES DOCUMENTATION

Released 6/30/99	SMS-100	Operations Concept for the Surface Management System (SMS)
Due 12/30/99	SMS-101	SMS Research & Development Plan (Volume I – Technical Plan & Volume II – Cost Plan)
Due 12/30/99	SMS-102	Operations Concept for the Surface Management System (SMS) Prototype

DEVELOPMENT DOCUMENTATION

REQUIREMENTS

Due 5/1/00	SMS-110	SMS System User Requirements (level I) Document (Results of user requirements analysis & agreements)
Due 9/30/01	SMS-111	SMS System Performance Requirements (level I) Document (Results of functional allocation, functional description)

REPORTS & ASSESSMENTS

Due 9/30/00	SMS-150	SMS Prototype Initial Simulations Report
Due 12/31/01	SMS-151	SMS Prototype Feasibility Report
Due 6/30/02	SMS-152	SMS Prototype Final Simulations Report
Due 12/31/03	SMS-153	SMS Prototype Validation Report
Due 9/31/03	SMS-154	SMS Prototypes Operational Evaluation Report

2.3 REFERENCE DOCUMENTS

1. D.Signor, C. Leidich, SMS-102, "Operations Concept for the Surface Management System Prototype", December 1999

2. U.S. DOT, FAA, 1998 Aviation Capacity Enhancement Plan.
Refer to: http://www.faa.gov/ats/asc/Pubs.html

3. NASA, AATT, Sub-element 4, "Terminal/Surface Systems and Operations, Level III Plan", Version 2.0, March 1999.

4. Willma Rada, "Surface Movement Advisor (SMA) Benefit Analysis", prepared by FAA/ASD and MCA Research Corp, October 1997.

3.0 RESEARCH APPROACH

3.1 TASK BREAKDOWN

Figures 3.1 (A) through 3.1 (F) shows a breakdown of the SMS R&D effort.

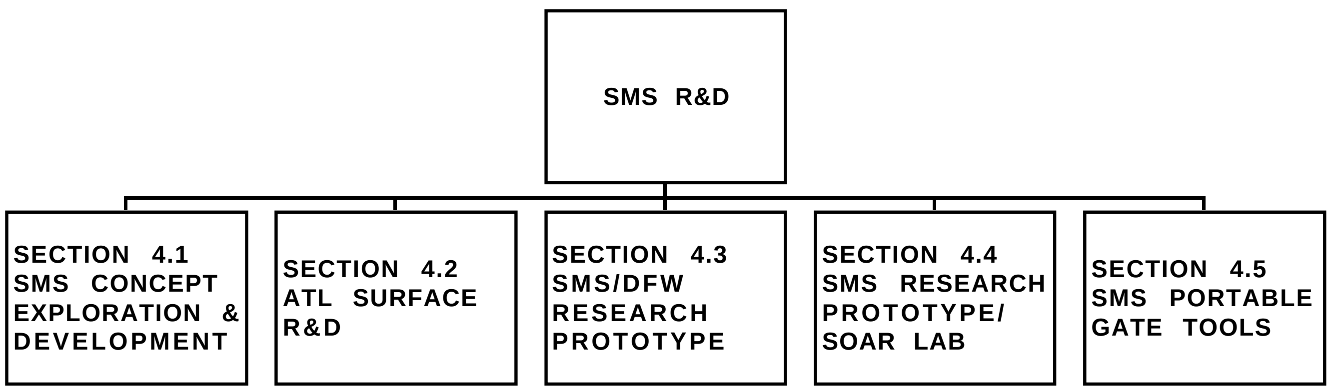

FIGURE 3.1 (A)
BREAKDOWN OF THE SMS R&D EFFORT

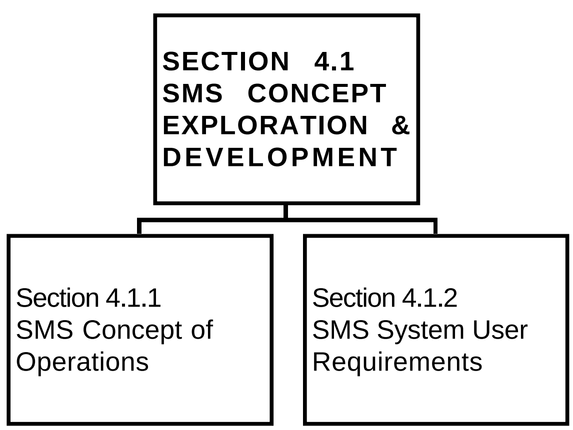

FIGURE 3.1 (B)
BREAKDOWN OF THE SMS CONCEPT EXPLORATION & DEVELOPMENT EFFORT

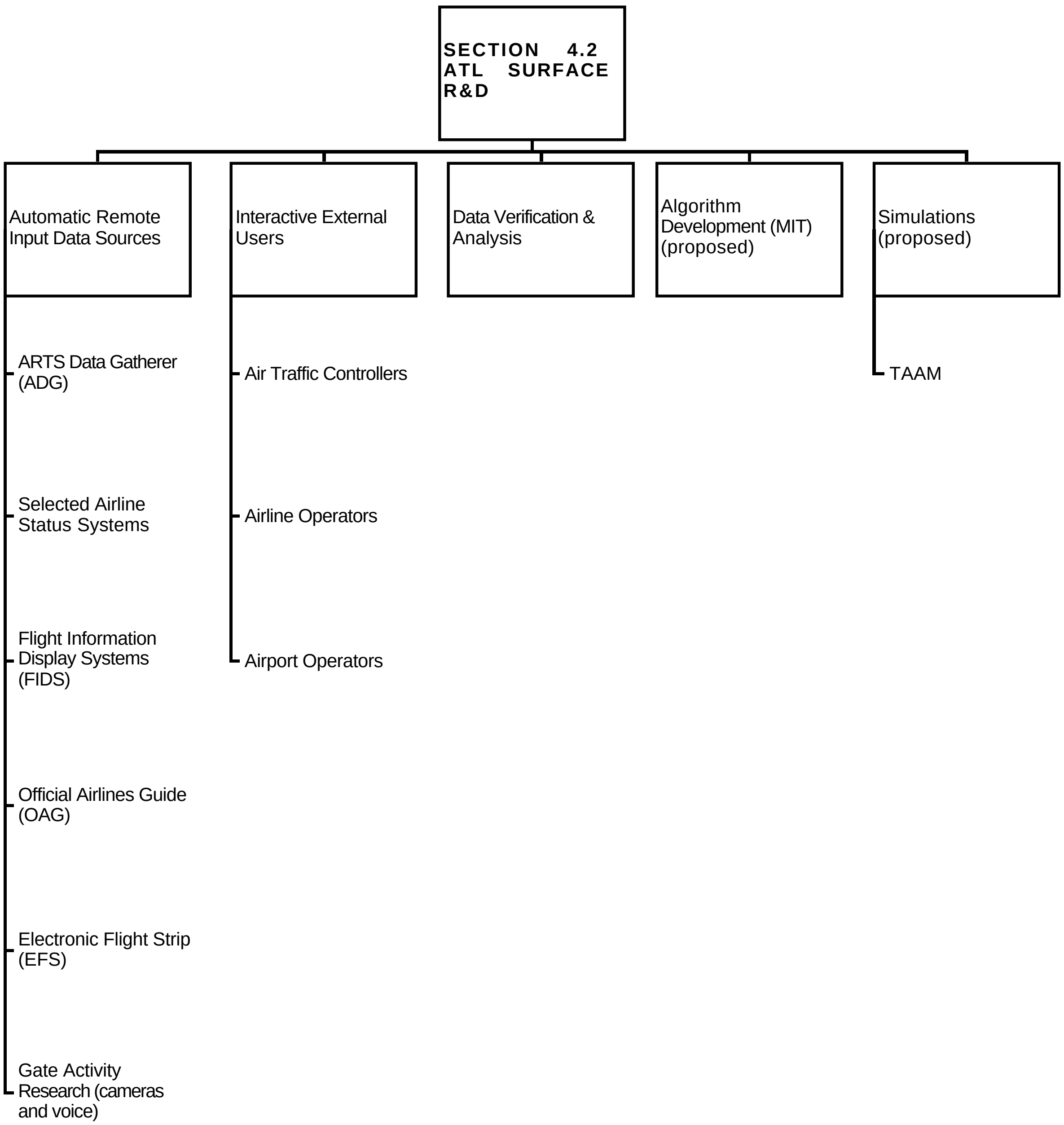

FIGURE 3.1 (C)
BREAKDOWN OF ATL SURFACE RESEARCH EFFORT

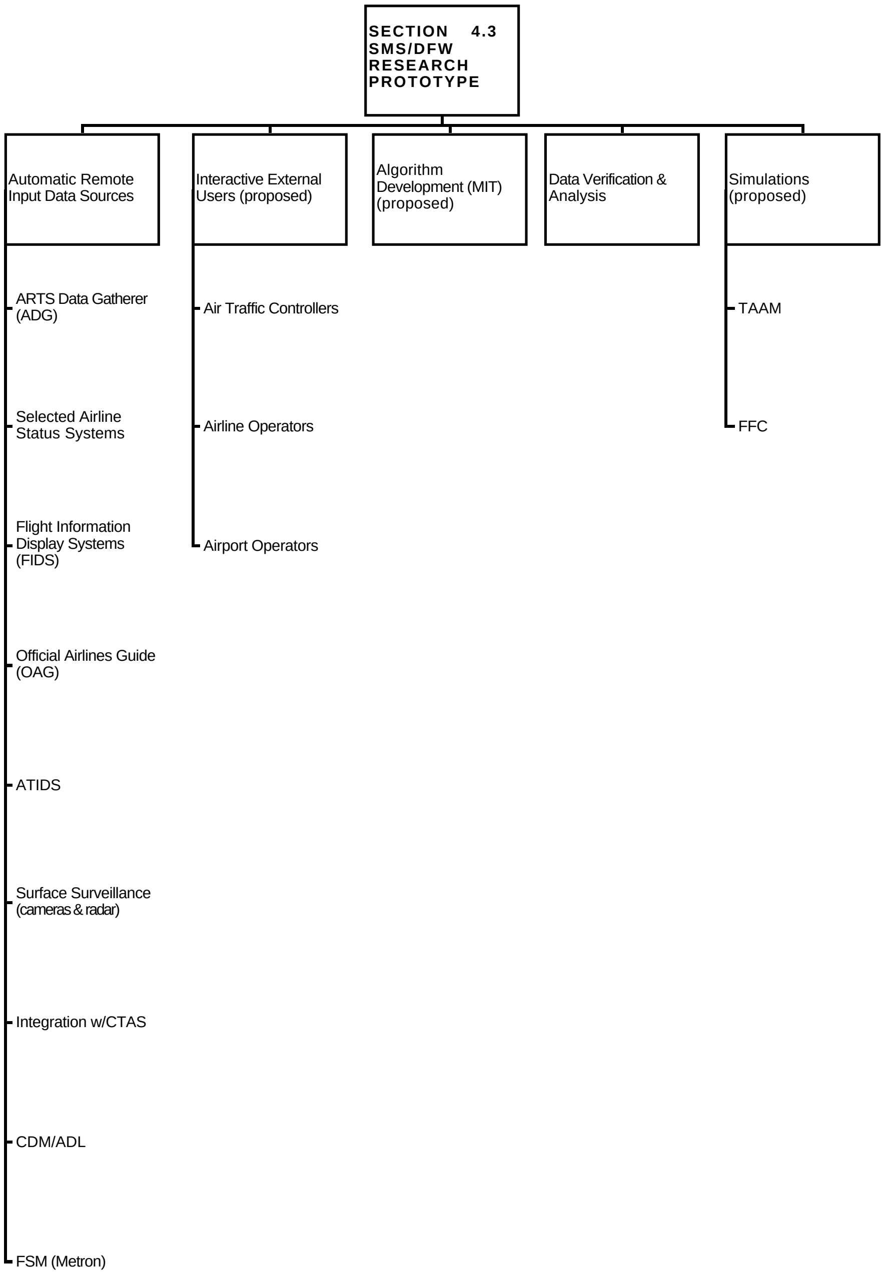

FIGURE 3.1 (D)
BREAKDOWN OF SMS/DFW RESEARCH PROTOTYPE EFFORT

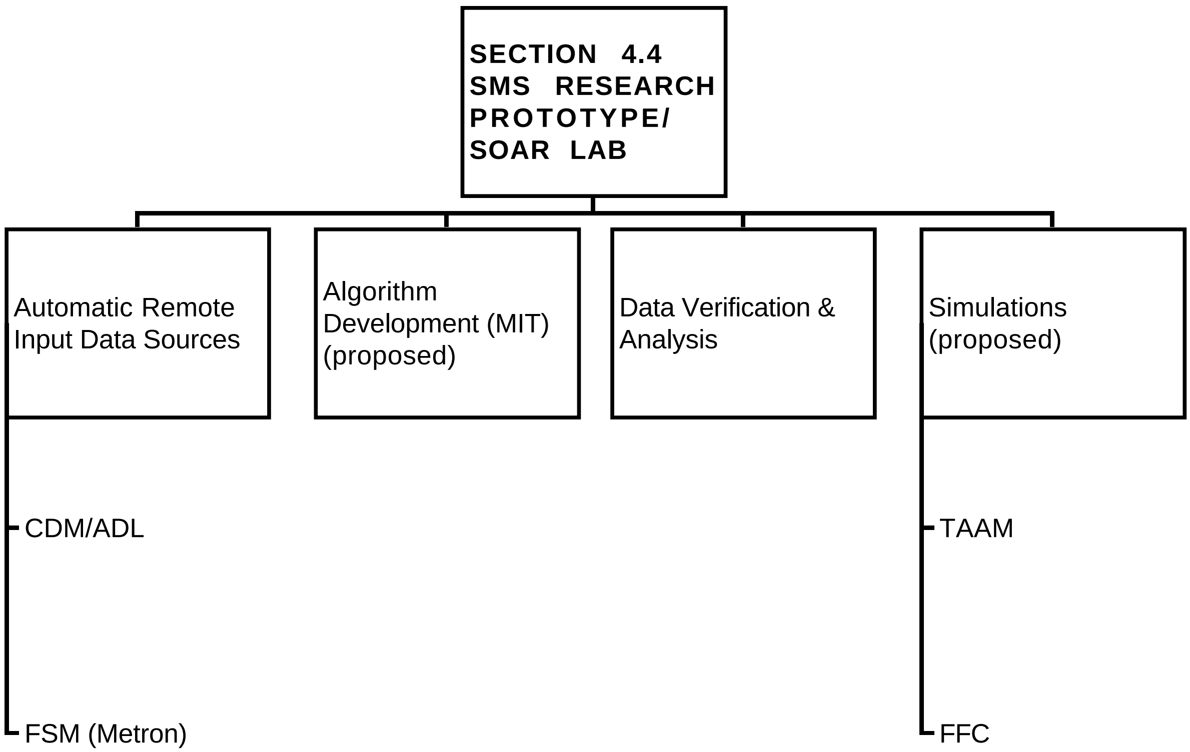

FIGURE 3.1 (E)
BREAKDOWN OF THE SMS RESEARCH PROTOTYPE/
SURFACE OPERATIONS AUTOMATION RESEARCH (SOAR) LAB

SECTION 4.5 SMS PORTABLE GATE TOOLS

FIGURE 3.1 (F)
BREAKDOWN OF THE SMS PORTABLE GATE TOOLS EFFORT

3.2 DESCRIPTION OF SMS RESEARCH AND DEVELOPMENT APPROACH

The following is the approach to developing the SMS prototype (see reference 1 in Section 2.3). To the maximum extent possible, the entire National Airspace System (NAS) will be studied as a system. Such an analysis requires the availability of national data feeds, e.g., Enhanced Traffic management System (ETMS) and Aggregate Demand List (ADL) into NASA/ARC.

Initially, a baseline analysis of the ADL data will be conducted (similar to that described in section 4.2), which will allow the effect of any subsequent NASA additions to the ADL to be quantified. In parallel with the baseline, analysis of the ADL data will be conducted to develop predictions and recommendations that will be considered for addition to the ADL.

Algorithms that are identified as being plausible for meeting the program goals will be simulated in the Total Airspace Aircraft Modeling Tool (TAAM) for selected airports. TAAM will be used to evaluate potential strategies and algorithms.

Then, NASA's Future Flight Central (FFC) will be employed to analyze the SMS/DFW research Prototype and the SMS Research Prototype/SOAR Lab. The FFC-based simulations will study and validate the various ways in which controllers and other human decision-makers will interact with SMS. The FFC testing will also be used to improve the surface/terminal models and tune the SMS algorithms and heuristics.

Algorithms and recommendations that survive the scrutiny of analysis and simulation will be implemented in the national SMS prototype at NASA/ARC, and the output will be added to the data sent back to Volpe for national distribution (via the ADL).

Solutions for specific users at specific airports will be implemented by NASA additions to the ADL, rather than fielding prototypes at individual airports, and attempting to extrapolate those local solutions to a more general solution.

Gate information from ATL or the ADL may not be accurate and timely enough to allow accurate and reliable predictions and recommendations.

Thus, methods of surface surveillance will be investigated and advocated, to supplement existing gate information and provide information not previously available. Currently these methods include, surface radar (MIT/LL multilateration), other radar techniques such as Automatic Dependent Surveillance (ADS)-B and Global Positioning System (GPS). A complete solution of the surface problems within the NAS will not be possible without tagged location information of most flights on the surface of most U.S. airports. Currently, the beginning of a complete surface surveillance system (based on the multilateration technique) is being built at DFW. Expanding this capability into a real-time and continuous data feed into SMS at DFW will be pursued. This will be intended to serve as a demonstration of what can be accomplished with surface surveillance as much as it will be intended to provide an immediate benefit to the local users.

Methods of acquiring detailed (timely and accurate) information about gate activity will be pursued. Current possibilities include image processing of remote video camera images, acoustic sensors, and input from wireless hand-held devices.

Voice recognition techniques will be investigated as a means of reducing the ramp/FAA controller workload.

Standardization of airline (gate) messages that are received into SMS will be advocated.

Algorithms that minimize de-icing delays will be investigated.

The secondary goal of portability will be addressed by (1) a national approach, wherein an intrusive installation at each airport (like SMA at ATL) is not necessary, and (2) developing tools to view the airport specific data that can easily be installed at any appropriate airport. In conjunction with the portability goal, a site survey of U.S. airports will be completed to determine which airports would benefit from SMS.

The secondary goal of integration with CTAS tools: Final Approach Spacing Tool (FAST), Collaborative Arrival Planning (CAP), and Enhanced Departure Planner (EDP) will be accomplished initially at DFW (see section 4.3).

Prototypes of applications that address specific problems will be fielded at various airports (see Sections 4.2 & 4.3). Such prototypes will have two purposes; (1) to meet users needs and, equally (2) to facilitate further research. The human factors group at Ames will be essential in developing any SMS prototype displays intended to assist controllers with decision making.

Finally, if NASA Ames successfully develops a national SMS, then the entire application, including source code, will be delivered to the FAA. NASA can not develop commercial products (software) for sale, so the research prototype will be given away, and a version will subsequently be built by a commercial non-NASA entity.

3.3 SAFETY/WORK ENVIRONMENT

All work related to the SMS R&D shall be performed in such a manner as to minimize risk to life, health, and safety of all personnel associated with the project and to minimize hazards to the health and safety of the general public.

Safe practices shall be implemented, the essential elements of which are as follows:

a) Designation of an organizational safety officer to plan, coordinate, and monitor safety practices (at the Atlanta field site the existing FAA safety officials and practices will apply)

b) adherence to existing safety regulations, as applicable, for state, county, municipal and organizational jurisdictions

c) safety notices, warnings, fire bells, posted in and around SMA work areas

d) safe work areas maintained by extra custodial services, facility and equipment arrangements, safety painting, use of protective screens, guards, and equipment as needed

The SMS R&D shall use equipment that conforms to Underwriters Laboratory (UL) Safety Standards.

3.4 METHODS

Methods for SMS R&D will be identified at the following website:

http://ace.arc.nasa.gov/cgi-bin/postdoc/get/postdoc/t/folder/main.ehtml?url_id=10763

Methods include NASA/ARC ISO9001 procedures and specific SMS R&D Processes & Procedures such as: configuration management, SW R&D/TestingTools, SW R&D Processes & SW Testing Processes.

4.0 SMS R&D TASKS BREAKDOWN

4.1 SMS CONCEPT OF EXPLORATION & DEVELOPMENT

4.1.1 SMS Concept of Operations

Purpose: The purpose of the SMS Concept of Operations document (document SMS-100) is to present a vision of a Surface Management System. This document is intended to be written from the perspective of the users application domain.

Deliverables: SMS Concept of Operations document & revisions

Timeframe: This effort will be on-going throughout the entire SMS research and development effort.

Milestones: This milestone (AATT Milestone 6.10) was completed with the release of Version 0 of the SMS Concept of Operations document. This document will be revised as appropriate throughout the SMS research and development effort.

Future AATT Milestones: None

4.1.2 SMS System User Requirements

Purpose: The purpose of this document (document SMS-110) is to map desires of the users from the SMS Concept of operations vision to System User requirements. These requirements also form the basis for operational "validation" assessment/testing. Validation establishes that the right system has been built.

These requirements will provide the starting point for a detailed functional analysis & functional allocation.

Deliverables: SMS System User Requirements (Level I) document & revisions

Timeframe: This effort will be ongoing throughout the entire SMS research and development duration.

Milestones: No AATT milestones were established for this document. This document will be revised as appropriate throughout the SMS research and development effort.

Future AATT Milestones: None

4.2 ATL SURFACE RESEARCH AND DEVELOPMENT

To begin, a data-warehouse containing several months of SMA data from ATL and weather data will be created. These data will be analyzed for two basic purposes.

1) A baseline of the current release of SMA running in ATL will be conducted. The baseline of ATL prior to release of SMA was not conducted. A subsequent study was made while SMA was turned off for a period of one-month (Ref. 4). Much of what is known about the benefit of SMA in ATL is based on this study. The current baseline activity will serve as a quantitative basis for comparison with any subsequent enhancements to SMA at ATL.

2) SMA at ATL and the data SMA generates will be used as a research tool. The data will be analyzed, with intent to develop algorithms that suggest the optimal pushback, and departure sequence. This is also known as Collaborative Departure Scheduling (CDS).

The CDS algorithms will be simulated in TAAM and FFC.

An investigation of the human factors concerns of making automated suggestions to FAA and ramp controllers will be conducted. Only algorithms that survive the scrutiny of the previous steps will be implemented at ATL.

In parallel with the above, remote video cameras with image processing will be used to check the accuracy of existing gate activity information. Also, research into semi-automating the inputs (to SMA) made by ramp controllers using voice recognition will be conducted.

In the ramp towers, SMA will advise pushback sequence, to begin building an optimum departure queue.

In the FAA Tower, SMA will advise taxi-start or taxi-entry times to sequence the departures as they enter the taxiway system from the ramps. This involves sequencing taxi-starts from the 14 entry spots.

These sequencing recommendations, which attempt to construct the optimized Virtual Queue, take into account a variety of factors, including airport configuration, runway capacity, taxi-way congestion, and trade-offs with terminal-area airspace constraints.

Opportunities for optimization occur when multiple aircraft pushback within one minute of each other, on the same ramp at Atlanta. For example, each day, on average, Ramp 2 has 60 opportunities to make a decision about the order in which two aircraft pushback (i.e., two aircraft push back within a one minute time window), 22 decision opportunities between three aircraft, and 3 decision opportunities between four aircraft. This analysis illustrates the level of controllability that is available over the departure sequence, as well as the number of decisions that controllers are currently making without any decision support. Therefore, providing advisories to manage the pushback sequence will help SMS construct the desired Virtual Queue. Note that taxi delays are largest during major pushes, when the most opportunities for re-sequencing aircraft will occur.

4.3 SMS/DFW RESEARCH PROTOTYPE

SMS at DFW will be integrated with various CTAS tools, for the purpose of providing surface information to arrivals and departures, shown in Figure 1.1.

The surface data that are necessary to accomplish the integration with CTAS are similar to the data at ATL. The desired model is to analyze the DFW specific data in the ADL, and add predictions and recommendations. In addition to the ADL, surface surveillance capability at DFW will be developed.

Some data (perhaps radar tracks and flight plans) may come directly from CTAS, rather than the ARTS as they do at ATL. Additionally, local weather data will be collected at DFW.

On the arrival side SMS will receive information from FAST and CAP. SMS will then feed back to FAST and CAP information about the current and expected conditions (at the gate) for specific flights.

On the departure side, SMS will feed information about the current and expected departure queue (probably for the next five aircraft to depart) to EDP. EDP will feedback information to SMS about departure vector loading so that SMS can make recommendations to the FAA ground controllers to avoid overloading any departure vector.

SMS will provide predictions of taxi-out time and departure time.

SMS will provide recommendations to FAA ground controllers and ramp controllers to assist them in building departure queues and coordinating arrival runway crossings, with the goal of minimizing surface congestion.

SMS at DFW will include ADL data, CTAS integration and surface surveillance data. Thus DFW will be the primary prototype of what can be accomplished with SMS.

4.4 SMS RESEARCH PROTOTYPE/SOAR LAB

A data-warehouse containing several months of SMS data from the ADL, ETMS and weather data will be created. These data will be analyzed for two basic purposes.

1) A baseline of the current surface conditions present in the NAS will be conducted. This baseline will serve as a quantitative basis for comparison with any subsequent enhancements to the surface operations within the NAS, via the NASA Ames additions to the ADL.

2) SMS will be used as a research tool. The data will be analyzed, with intent to develop algorithms that suggest the optimal pushback, and departure sequence. This is also known as Collaborative Departure Scheduling (CDS). The SMS prototype (running at NASA Ames) will add two types of information to the ADL:

   (a) predictions

   (b) recommendations (to controllers)

This information (added to the ADL at NASA Ames) will be passed back to Volpe/Metron and then to the recipients of the ADL.

Examples of predictions added to the ADL include:

- taxi out time
- take off time

These can be used for better en-route planning.

Examples of recommendations to ramp controllers and FAA ground controllers include:

- pushback sequence
- departure queue sequence

These will help minimize congestion, maximize throughput and minimize de-icing delays. Also, airborne holding can be accommodated if the information that a desired gate will be occupied when an arrival flight needs it is available prior to descent and landing

The CDS algorithms will be simulated in TAAM and FFC.

An investigation of the human factors concerns of making automated suggestions to ramp and FAA controllers will be conducted. Only algorithms that survive the scrutiny of analysis and simulation will be implemented.

4.5 SMS PORTABLE GATE TOOLS RESEARCH

TBS

APPENDIX ACRONYMS & ABBREVIATIONS

a/c	aircraft
AATT	Advanced Air Transportation Technologies (AATT) Program (a NASA Program)
ADG	ARTS Data Gatherer
ADL	Aggregate Demand List
ADS	Automatic Dependent Surveillance
AGI	Airport Group International (the company that provides ramp controllers for concourse C and E in Atlanta).
AOC	Airline Operations Center
ARC	Ames Research Center
ARTS	Automated Radar Tracking System
ASD	ASD is an organization within the FAA
AST	Aviation Surface Technologies
ATIDS	Airport Target Identification System
ATM	Automated Traffic Management
CAP	Collaborative Arrival Planning
CDM	Collaborative Decision Making
CDS	Collaborative Departure scheduling
CNS	Communications, Navigation and Surveillance
COTS	commercial off-the-shelf
CTAS	Center-TRACON Automation System
DOA	Department of Aviation
DOT	department of Transportation
DST	Decision Support Tool
DTA	Departure Transition Area
EDP	Enhanced Departure Planner
EFS	Electronic Flight Strip
ETMS	Enhanced Traffic Management System
FAA	Federal Aviation Administration
FAST	Final Approach Spacing Tool
FFC	Future Flight Central (at NASA/ARC)
FSM	Flight Schedule Monitor
GPS	Global Positioning System
IV&V	Independent Verification and Validation
LL	Lincoln Labs

Mgr	Manager
MCA	MCA Research Corporation
MIT	Massachuchetts Institute of Technology
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
OAG	Official Airlines Guide
R&D	Research & Development
SMA	Surface Management Advisor (at ATL)
SMS	Surface Management System
SOAR	Surface Automation Operations Research Laboratory (at NASA/ARC)
TAAM	Total Airspace Aircraft Modeling Tool
TRACON	Terminal Radar Approach Control
TRL	Technology Readiness Level
TMA	Traffic Management Advisor
TMU	Traffic Management Unit
VDQ	Virtual Departure Queue